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REPORT

on

WATER QUALITY

in

CAMERON LAKE

1971

RECREATIONAL LAKES PROGRAM

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THE
ONTARIO WATER RESOURCES COMMISSION
REPORT
ON WATER QUALITY

IN
CAMERON LAKE

1971

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SUMMARY

A study to evaluate the status of water quality in Cameron Lake was carried out during the summer of 1971.

Cameron Lake lies in the Trenton Bedrock Formation which is a flat limestone bedrock buried beneath a deep mantle of different textured materials. The area around Fenelon Falls as well as along the north and south-west shoreline has shallow gravelly overburden and the remaining shoreline has over 2 meters (7 feet) of various soils with good local drainage.

A well-defined thermocline or zone of rapid temperature decline was observed between the upper warm waters (epilimnion) and the cool bottom waters (hypolimnion) during June and July. During this period, bottom water saturations of dissolved oxygen were lower and carbon dioxide values were considerably higher than in the surface waters as a result of decomposition of organic matter. In September, uniform temperature and dissolved oxygen profiles were apparent throughout the lake indicating the effect of vertical mixing processes. During the late spring and early summer months, dissolved oxygen conditions were not sufficient to maintain cold-water species of fish.

The unenriched nature of the lake was revealed by the mean values for total Kjeldahl nitrogen (0.27 mg/l) and total phosphorus (0.016 mg/l), two nutrients critical for aquatic plant and algae growth.

Algal levels as measured by chlorophyll a concentrations were generally low during the periods sampled. These low algal levels would not be expected to reduce water quality for recreational activities or diminish the aesthetic quality of the lake.

Generally Cameron Lake was within the OWRC bacteriological criteria for recreational use during four of the five surveys completed in 1970 and 1971. However, bacterial numbers did increase, following spring rainfalls in 1971, to levels constituting a public health hazard. Consistently higher bacterial levels were observed near the mouth of the Rosedale River.

In view of the evidence indicating artificial inputs of bacteria, every effort should be made to ensure that direct flow or leachate from domestic waste disposal systems or other potential sources of pollution do not gain access to the lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw or inadequately treated wastes must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths

impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Cameron Lake in the summer of 1971. This study included the assessment of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Physical, chemical and biological surveys were conducted four times in 1971. Three bacteriological surveys were also conducted; a spring survey from June 18 to 22, a mid-summer survey from July 23 to August 2 and a fall survey from September 10 to 14 inclusive. Sampling each day for a minimum of five days is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

The "Kawartha Lakes Water Management Study" was also initiated in 1971 to examine the complex problems of eutrophication which exist in the Kawartha Lakes. The broad objective of this study is to develop a water management plan to protect and develop the recreational potential of the watershed.

Included in this study are programs to evaluate the trophic status of the lakes, the sources of nutrients to the lakes, the nutrient cycling systems within the lakes and the specific effects on the water environment of various wastewater inputs. An experiment is also planned to evaluate weed cropping, both as a method of enhancing the recreational use of a lake and of providing a nutrient drain that could significantly reduce the quantity of nutrients available for plant growth in the future. Along with this experiment, effects of weed cropping on the sports fishery of a lake is being evaluated by fisheries biologists of the Department of Lands and Forests (now within the Ministry of Natural Resources). The study is expected to continue for at least three years and some data from the first year is included in this report.

A joint federal-provincial study committee (CORTS) has recently released a report entitled "The Rideau-Trent-Severn - Yesterday Today Tomorrow" which considers optimum recreational development of the Rideau-Trent-Severn waterway corridor which includes part of the Kawartha Lakes. Water and other environmental pollution problems received the highest priority in the list of recommendations in this report which was started in 1967. Other recommendations were made dealing with the use of open space, historical preservation and interpretation, public use areas and other topics designed to develop the corridor as a recreation resource. Many of the recommendations of this report have already been implemented by various federal and provincial agencies such as nutrient budget studies and correction of industrial waste discharges to the waterway.

AREA DESCRIPTION

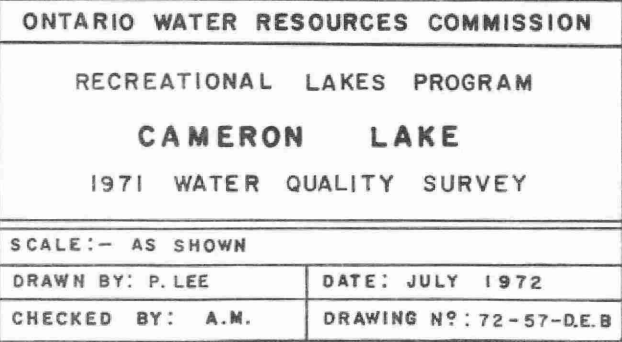
Geography and Topography

Cameron Lake is located in the Township of Fenelon, Victoria County, and spans the area between the Hamlet of Rosedale and the Village of Fenelon Falls.

The lake is egg-shaped with a surface area of 14 square kilometres (3,400 acres) and a shoreline length of 29 kilometers (18 miles). The lake has a relatively flat bottom and is about 9 to 12 meters (30 to 40 feet) in depth, with a maximum depth of 18 meters (60 feet).

The immediate watershed of the lake, excluding the waters from the Burnt River and the Trent Canal, is 120 square kilometers (29,700 acres). Most of the surrounding area is characterized by a loam type soil belonging to the Otonabee, Dummer and Bondhead soil series. The remainder of the area belongs to the Muck soil series. The most predominant soil type is the Otonabee series which occupies most of the area along the southern and western shores of Cameron Lake. This series is a well-drained, sandy loam, textured, glacial till containing a moderate amount of stone. Its profile development shows some of the characteristics of both the Brown Forest Great Soil Group and of the Grey-Brown Podzolic soils. The Dummer series is located on the east shore between Fenelon Falls and the mouth of Fell's Bay. This series is a very stony, calcareous, gravelly loam with good drainage. The profile is thin and is characteristic of the Brown Forest soils of Ontario. The Bondhead series is partly found in Fell's Bay and consists of a well drained, calcareous, sandy loam, textured, glacial till that is moderately stony. Its soil development is typically that of the Grey-Brown Podzolic soils. The Muck series located in the area around Cranberry Bay and the west half of Fell's Bay and in the south portion of

FIGURE 1



Sackett Bay, is made up of organic deposits. There are 46 centimeters (18 inches) or more of organic material overlying the mineral soil. The organic material is partially decomposed remains of sedges and trees.

Climatic Range

The area has a mean daily temperature of -8°C (17°F) in January and a mean temperature of 20°C (68°F) in July. The mean annual precipitation is 80 centimeters (32 inches) including 200 centimeters (80 inches) of snow. According to meteorological reports, the area enjoys about 240 days yearly with no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow, provides for participation in most winter sports.

Water Movement

Cameron Lake is part of the Bay of Quinte Terminal Drainage Basin. It is one of the Kawartha Lakes which serve as great reservoirs for the Trent River System. The waters of the system enter the lake from the north end of the west shore via the Trent Canal and leave through its only outlet by Fenelon Falls via the Fenelon River. The lake's other main inflow is the Burnt River which enters the lake just north of the Trent Canal. There are two inflows, Perrin and Martin creeks, entering the lake at McFarland and Sackett bays respectively. Two locks situated at Rosedale and Fenelon Falls are operated by the Federal Ministry of Transport Canals Division, Trent Canal System. They drop approximately 1 meter (3.5 feet) and 7 meters (23 feet) respectively.

Shoreline Development

The shoreline of Cameron Lake is well developed with the exception of

Cranberry Bay and the north half of the east shore. There are approximately 500 closely spaced summer cottages, 2 privately-owned resorts, 3 trailer camps and a public beach and park. The community of Rosedale is located between Balsam and Cameron Lakes. Property locations and densities of development are shown in Figure 1.

Water Usage

The majority of cottage owners and the Village of Fenelon Falls use the lake as their source of domestic water supply. The average daily consumption by the village in 1970 amounted to 773 kiloliters (170,000 gallons) per day with plant storage amounting to 26 kiloliters (5,700 gallons). The lake supports recreational water sports such as fishing, boating, water skiing and swimming. Fishing for bass, pickerel and maskinonge is reasonably good.

Cameron Lake is part of the Trent Canal System and according to the Department of Tourism and Information, 18,516 boats used the system in 1969. Boaters spent an estimated \$8.6 million and an additional \$3.6 million was spent by the Federal Department of Transport for operation, maintenance and capital expenditure. Thus, \$12.2 million was injected into the economy of those areas adjacent to the Trent Canal in 1969.

Presently, there are no direct discharges of wastes into Cameron Lake from municipal or industrial sewage treatment facilities. The area residents are provided with a municipal solid waste disposal site located outside of Fenelon Falls on Lot 22, Concession XI, Township of Fenelon. However, this site is to be closed in the spring of 1972 and moved to Lot 31, Concession II, Township of Verulam.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

In selecting the physical, chemical and biological sampling sites on Cameron Lake an endeavour was made to choose the deepest locations. As well, a sufficient number of additional stations were sampled to represent adequately the entire lake (Figure 1.).

Temperature profiles were determined at each station using a telethermometer. Dissolved oxygen levels were measured using the alkalide azide modification of the Winkler method (Standard Methods 13th Edition). Additionally, samples for pH, total alkalinity and free carbon dioxide were collected 1m below the surface and 1m above bottom using a Van Dorn water sampler. The total alkalinity and free carbon dioxide concentrations were determined titrimetrically at the mobile laboratory located at Trent University, Peterborough.

At each station, two 32-ounce samples were collected using a composite sampler lowered through the euphotic zone (2x Secchi disc) or lowered to 1m above bottom whichever was less. One sample, for chlorophyll analysis, was immediately preserved with 10 - 15 drops of 2% MgCO_3 suspension. The second was divided into two sub-samples; the first sub-sample was frozen for phosphorus and nitrogen analyses, and the second was refrigerated and subsequently analyzed for iron and hardness. In addition when the euphotic zone did not extend to the bottom, samples were collected from 1m above the sediment using a Van Dorn sampler and submitted for phosphorus, nitrogen, iron and hardness.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths from 600 to 750 m μ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Two five-day intensive bacteriological surveys were completed on Cameron Lake during June and September and one eleven-day survey during July-August. In the June and July-August surveys 28 stations were sampled each day at a depth of 1 meter below the surface using sterile, autoclavable, polycarbonate 250 ml bottles. An additional sample was collected at Station 16D (Figure 4) one meter above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes. In the September survey, Stations 17, 24, 27 and 28 were removed because of loss of mobile laboratory personnel.

All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration (MF) technique (Standard Methods 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. These

"indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms,

indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on a lake can be grouped, by this method, into areas or groups of stations with the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration can be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analyses of variance program (ANOVA-CRE: Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed. Both these assumptions were checked

on Cameron Lake. The Bartlett's test was found to be non-significant and the data followed a normal distribution, so the analysis of variance (F-test; Sokal, 1969) was calculated in all the stations. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn-stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

On Cameron Lake, three stations were established for measuring temperature and dissolved oxygen profiles (C-4, C-5 and C-6, Figure 1).

In June, a well-defined thermocline or zone of rapid temperature decline was apparent between 5 and 7m (Figure 2a). During the July survey (Figure 2b) this zone was approximately 3m deeper than during the preceding survey. There was not a well-defined thermocline in August, as temperatures decreased uniformly between the surface (22.5°C) and bottom (15.0°C) waters (Figure 2c). Complete vertical mixing of the water was evident in September (Figure 2d), at which time the temperature was considerably cooler than during the preceding surveys, indicating autumnal cooling of the lake.

Dissolved oxygen saturations during the spring and summer surveys varied from 89 to 109% saturation (Figure 2a, 2b & 2c) in the surface waters whereas levels immediately above bottom were generally less than 50% (Figure 2a) and as low as 1% (Figure 2c). This severe oxygen depletion resulted from bacterial oxidation of organic matter, biological respiration and chemical oxidation. During the late spring and early summer months, dissolved oxygen conditions in the deeper strata were not sufficient to maintain cold water species of fish such as lake trout, whitefish and herring.

pH, Free Carbon Dioxide, Total Alkalinity, Hardness and Conductivity

In Cameron Lake, surface pH values generally were near neutral (Table 1), and showed only minor fluctuations throughout the season. Surface pH values were usually higher (7.0-7.6) than those of the deeper strata (6.5-7.3).

Surface water carbon dioxide levels were low throughout the year (Table 1.). During June, July and August concentrations were generally higher in the deeper waters than in the surface strata. Specifically, on July 21 at Station C-5 concentrations at 1 and 13m were 1.7 and 10.6 mg/l respectively. The high

carbon dioxide levels and depressed pH values in the bottom waters are related to conditions of organic decomposition.

Total alkalinity and hardness values for the lake were higher in May and gradually decreased through the sampling season. Mean values for the four months were 53, 48, 47 and 41 mg/l for alkalinity and 62, 61, 58 and 53 mg/l for hardness, indicating a moderately soft-water lake. The seasonal changes to softer water conditions relate primarily to dilution from inflowing head water streams originating in the Haliburton Highlands, a soft-water area in the Precambrian Shield flowing into Cameron Lake via Gull River, Burnt River and Balsam Lake.

The lake was characterized by relatively low conductivity readings (Table 1) which averaged 137 $\mu\text{mhos}/\text{cm}^3$. Surface and bottom values differed by less than 10 $\mu\text{mhos}/\text{cm}^3$ in most cases.

Iron

Euphotic zone and bottom iron concentrations were very low (Table 2) with values ranging from 0.00 to 0.10 mg/l and from 0.00 and 0.20 mg/l respectively. The low bottom water values were evidence that an iron-phosphorus recycling mechanism, which recycles nutrients from the sediments for algal growth was not occurring during the warm weather survey period.

Total Kjeldahl Nitrogen and Total Phosphorus

The relatively low mean values for total Kjeldahl nitrogen (0.27 mg/l) and total phosphorus (0.016 mg/l) were indicative of the unproductive status of the lake. In general, troublesome levels of algae do not appear when total phosphorus concentrations are less than 0.020 mg/l. The mean value for total

phosphorus in Cameron Lake (0.016 mg/l) was below this limit and was consistent with the observed low chlorophyll a concentrations. Further inputs from municipal drainage, agricultural runoff and from malfunctioning or improperly installed domestic waste disposal systems will serve to accelerate the process of eutrophication.

Chlorophyll a

Algal levels, as reflected by chlorophyll a concentrations were moderately low during the sampling periods ranging from 1.5 to 4.6 ug/l. The mean concentration for all stations was 2.6 ug/l. These low algal levels would not be expected to reduce water quality for recreational activities or diminish the aesthetic quality of the lake.

Water clarity, which is one of the more important parameters used in defining water quality, can be measured using a Secchi disc. Figure 3 presents a chlorophyll a - Secchi disc relationship for a number of surface waters and clarifies the "trophic status" of Cameron Lake relative to numerous other well-known recreational lakes in the Province (see Brown 1972 for derivation of chlorophyll a - Secchi disc relationships). The oligotrophic to early mesotrophic status of Cameron Lake is indicated in Figure 3, by its proximity to values computed for Lake Ontario and the Eastern Basin of Lake Erie - two oligotrophic to mesotrophic lakes.

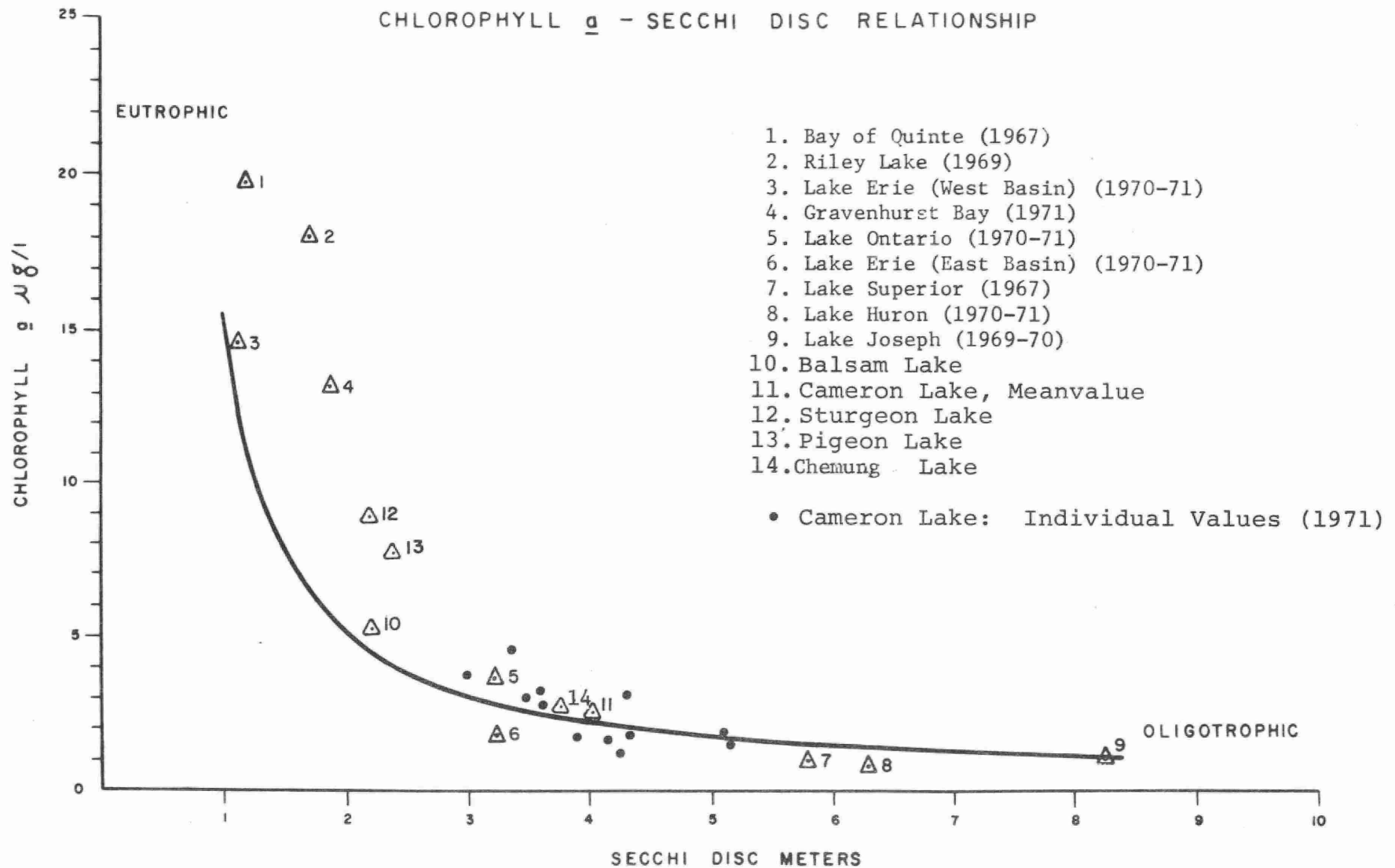
Bacteriology

Cameron Lake, generally, was well within the OWRC criteria for total body contact recreational use (OWRC, 1970) during the three 1971 surveys.

In the June survey, the majority of lake stations were included in Group A (Figure 4) with overall bacterial geometric means of 650 TC/100 ml,

FIGURE 3

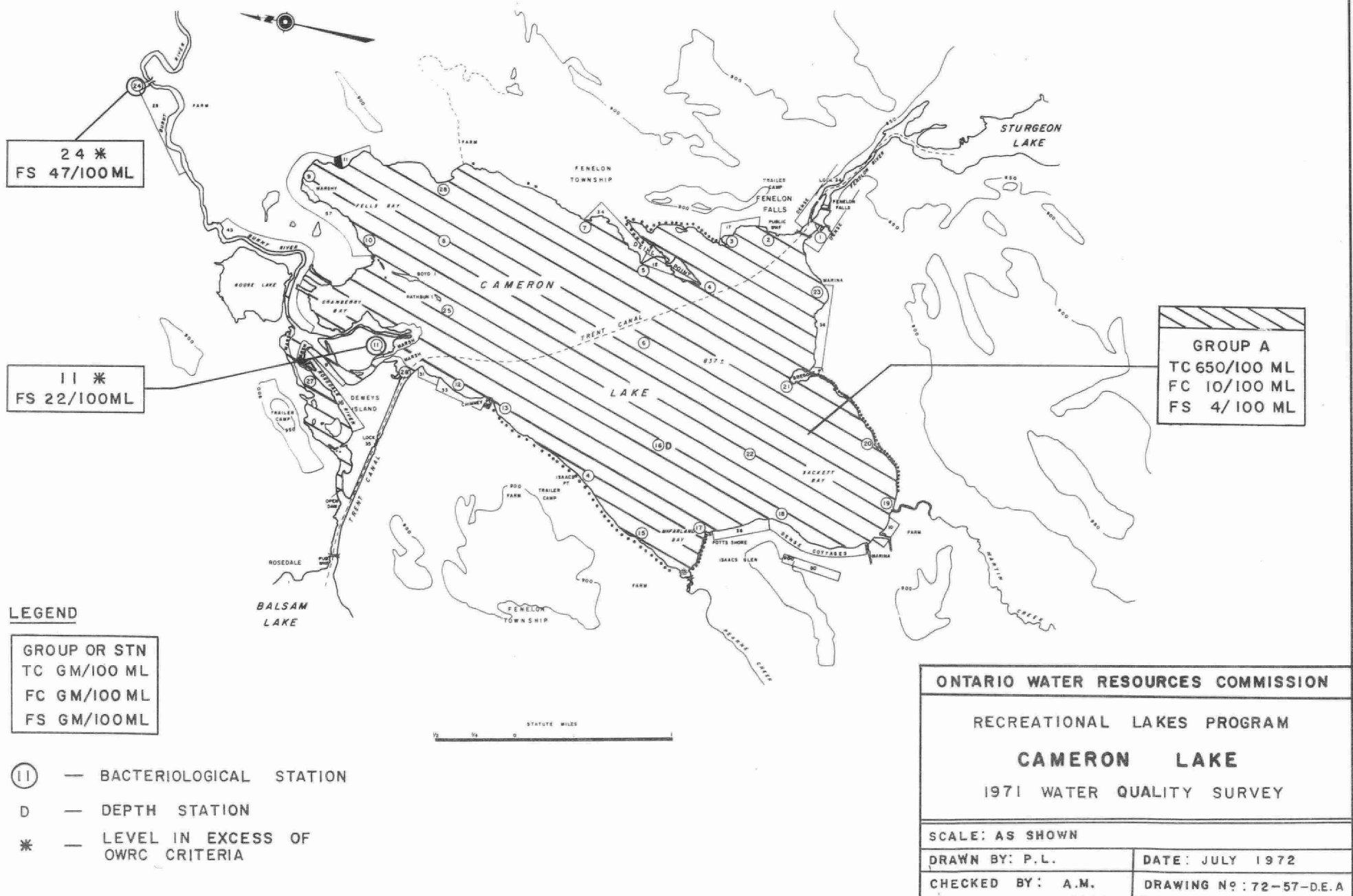
CHLOROPHYLL a - SECCHI DISC RELATIONSHIP



CAMERON LAKE

JUNE 18 - 22, 1971

FIGURE - 4



10 FC/100 ml and 4 FS/100 ml (Tables 3, 4, 5). Station 24, on the Burnt River, and Station 11, at the swampy inflow of the Rosedale River, had significantly higher FS levels 47/100 ml and 22/100 ml respectively, both exceeding the OWRC FS criteria. The Lindsay Climatological Station recorded a heavy rainfall of 1.48 inches on June 20. The FS levels at Stations 11 and 24 were highest on the last two days of the survey following the June 20 rain, and were attributed to runoff entering the lake via the Burnt and Rosedale rivers.

On June 20, the bacterial populations increased drastically with all TC, FC and many FS plates being grossly overgrown and uncountable and the TC levels remained excessively high at most stations on June 21. Even though the levels could not be quantitatively determined, they were well in excess of 1000 TC/100 ml and 100 FC/100 ml for every station, implying a short-term public health hazard.

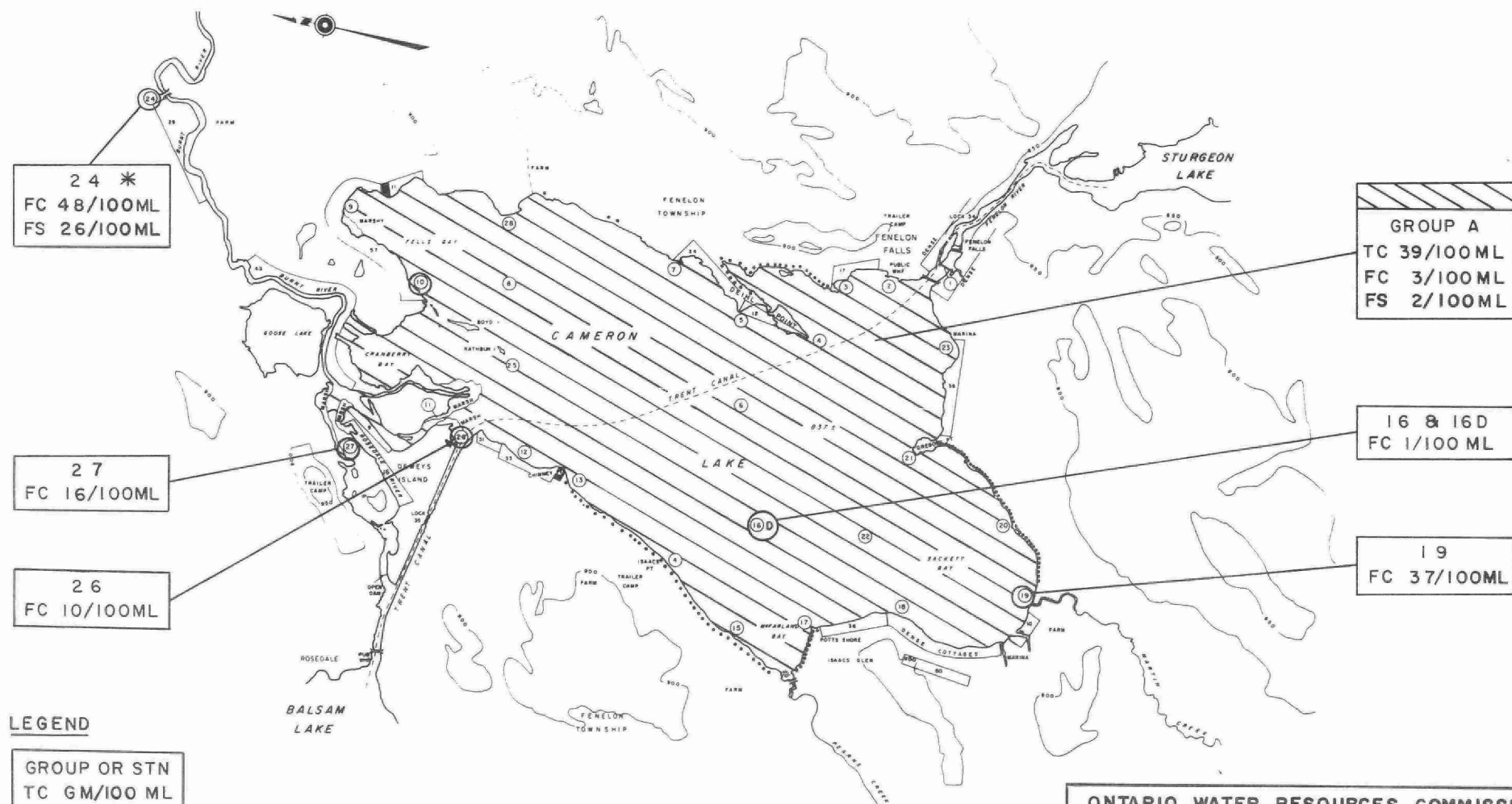
During the July survey, the entire lake was homogeneous (Group A) with overall bacterial means of 39 TC/100 ml, 3 FC/100 ml and 2 FS/100 ml, with the exception of the mid-lake Stations 16 and 16D, both 1 FC/100 ml, and four significantly higher inflow stations (Figure 5, Tables 3, 4, 5).

Station 24, on the Burnt River, had significantly higher FC and FS levels of 48/100 ml and 26/100 ml respectively. Although this station was included in Group A for TC, it had the highest TC level of any station, at 152 TC/100 ml.

CAMERON LAKE

JULY 23 - AUG. 2, 1971

FIGURE - 5



LEGEND

GROUP OR STN
 TC GM/100 ML
 FC GM/100 ML
 FS GM/100 ML

- ① — BACTERIOLOGICAL STATION
 D — DEPTH STATION
 * — LEVEL IN EXCESS OF
 OWRC CRITERIA

ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

CAMERON LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: P. LEE

DATE: JULY 1972

CHECKED BY: A.M.

DRAWING NO: 72-57-DE.A

Station 26, at the outflow of the Trent Canal through Lock 35, and Station 27, in the Rosedale River adjacent to a small, but heavily used, trailer camp, displayed higher FC concentrations of 10/100 ml and 16/100 ml respectively. These higher numbers have been attributed to a bacterial input from the Village of Rosedale, several large marinas and many lodges and cottages along the Rosedale River. Station 19, at the mouth of Martin Creek which runs through farmland, had a significantly higher FC level of 37/100 ml (Figure 5).

In September, the entire lake was homogeneous (Group A) with bacterial geometric means of 46 TC/100 ml, 3 FC/100 ml and 2 FS/100 ml (Figure 6, Tables 3, 4, 5).

The June survey had significantly higher TC, FC and FS levels than both the July and September surveys, which were uniformly low (Table 6). The higher June bacterial densities were attributed to contaminated spring runoff from the lake shore. Cameron Lake, in June, appeared to be very susceptible to rainfall induced runoff, with fluctuating bacterial populations resulting in a possible short-term public health hazard.

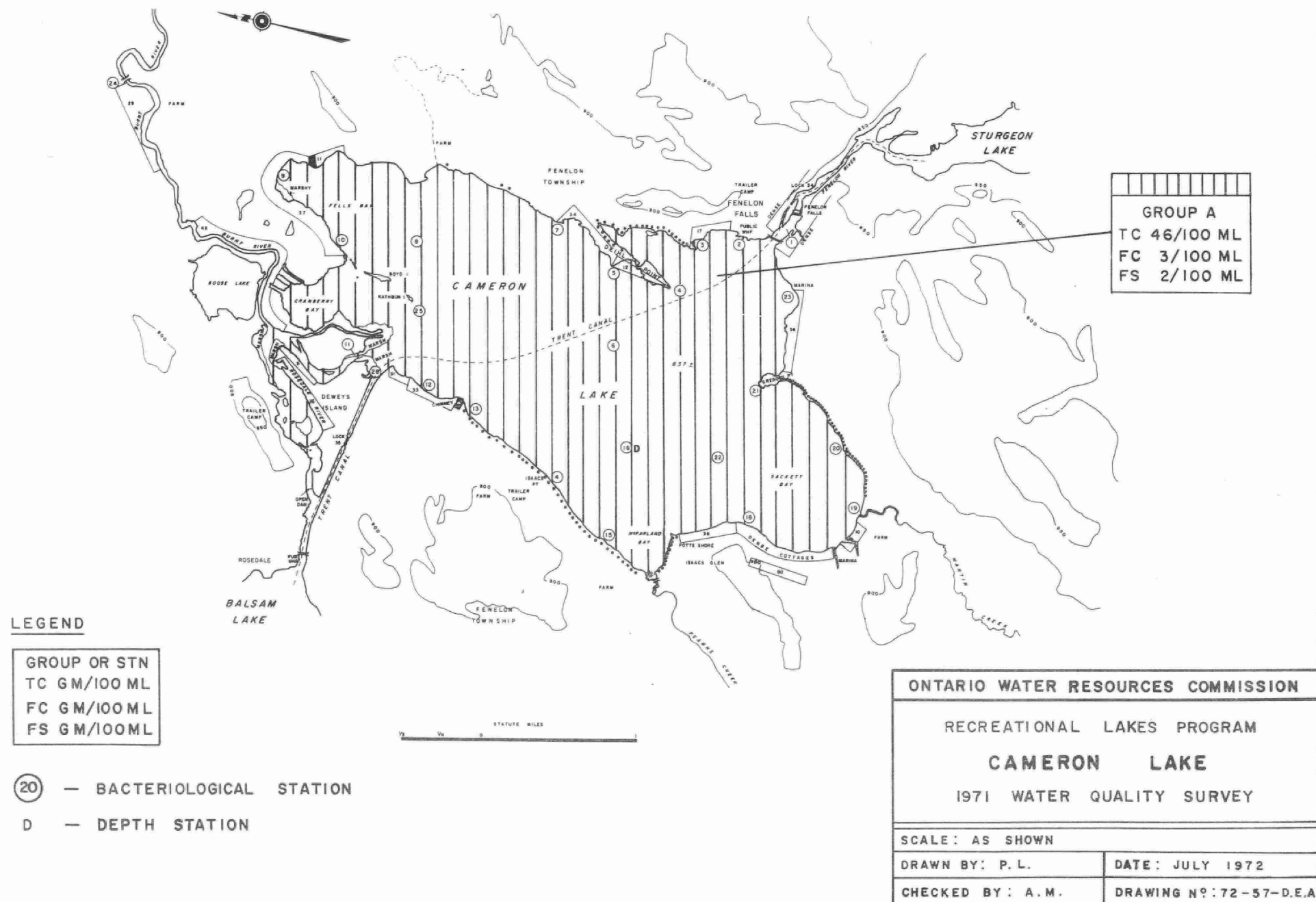
Cameron Lake was surveyed once in 1970 from August 17 to 21 (OWRC, 1971). In the 1971 surveys, some stations were added while others were slightly relocated (Figure 7). The 1970 raw data was run through the ANOVA-CRE program to facilitate comparison with the 1971 surveys.

In the 1970 survey, the majority of lake stations were included in Group A, with bacterial geometric means of 450 TC/100 ml, 16 FC/100 ml and 3 FS/100 ml (Figure 7). Group B, encompassing the inflows from the Rosedale River and Trent Canal, with a significantly higher TC level of 1555/100 ml, was well

CAMERON LAKE

SEPT. 10-14, 1971

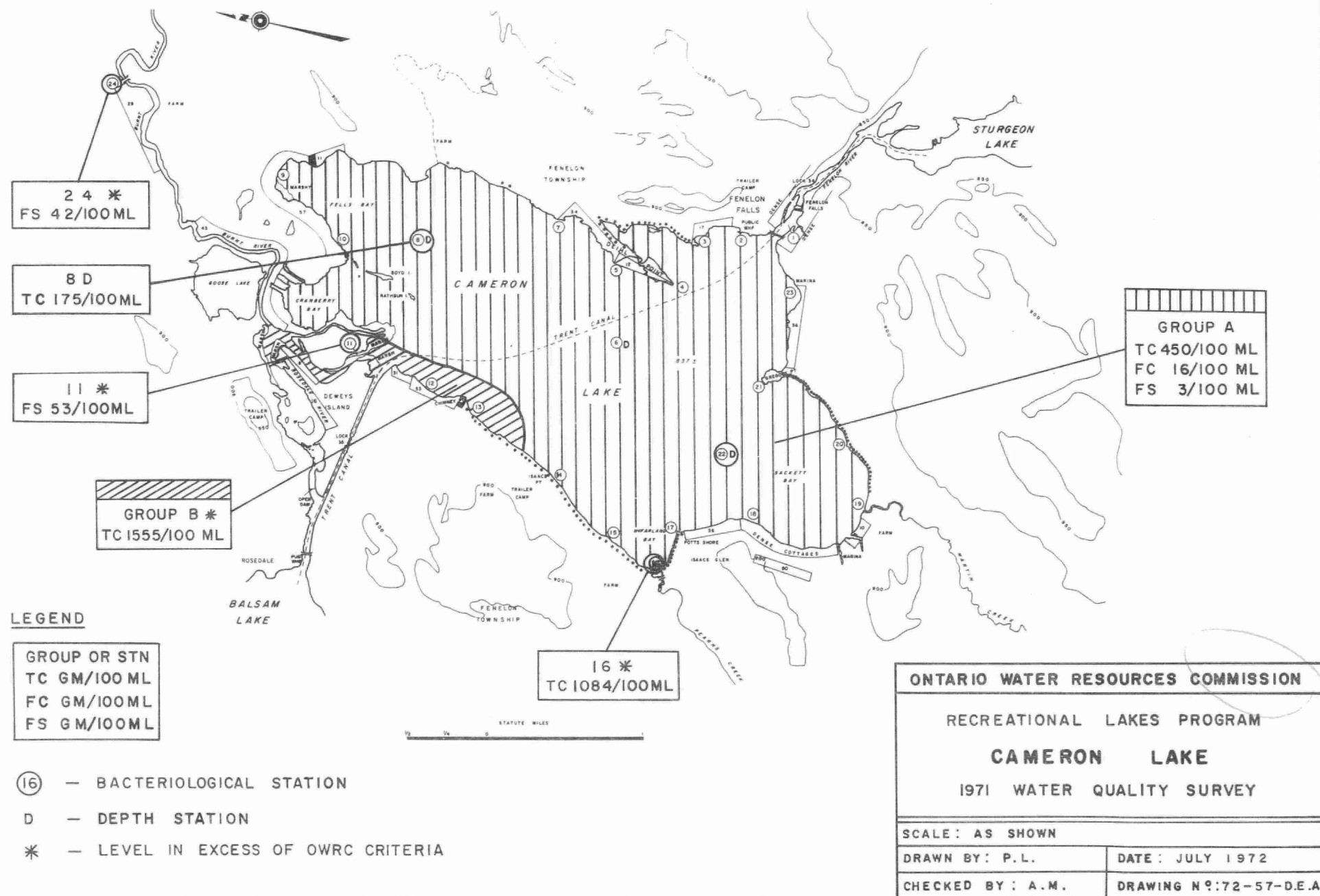
FIGURE - 5



CAMERON LAKE

AUG. 17 - 21, 1970

FIGURE - 7



in excess of the OWRC criteria. Station 16, at the mouth of Perrins Creek, also exceeded the criteria with 1084 TC/100 ml. Station 8D had a lower TC level of 175/100 ml, while Stations 11 and 24 had significantly higher FS concentrations of 53/100 ml and 42/100 ml respectively (Table 7).

The 1970 August survey had significantly higher TC and FC levels than the 1971 July survey (TC, student's t , $t = 13.663$, degrees of freedom, $df = 319$; FC, $t = 10.400$, $df = 311$) but equally low FS densities ($t = 1.2844$, $df = 345$).

Generally, Cameron Lake fell within the OWRC criteria for total body contact recreational use (OWRC, 1970) during the four surveys completed in 1970, 1971. However, the bacterial populations did increase to levels constituting a public health hazard in the inflow areas in August 1970 and following the spring rainfall in 1971. A bacterial input was detected from the Burnt and Rosedale rivers in both years. 

All surface water especially that drawn from the northwest end of the lake near the inflows must receive prior treatment including disinfection before it is considered safe for human consumption.

Data ranges for temperature, dissolved oxygen, pH, carbon dioxide, alkalinity and conductivity for Stations C-4, C-5 and C-6 on Cameron Lake.

Table 1

Station	Date	Sample Depth	Temperature (°C)	D. O. (% Sat)	pH	CO ₂ (mg/l)	Alkalinity (mg/l)	Conductivity (µmhos/cm ³)
C-4	1971	1m	16.0 - 23.4	92 - 98	7.4 - 7.5	2.3 - 4.0	41.2 - 52.0	107 - 155
		bottom	14.0 - 19.1	8 - 91	6.5 - 7.1	4.1 - 8.9	40.5 - 55.0	111 - 155
C-5	1971	1m	16.1 - 23.8	89 - 95	7.0 - 7.6	1.7 - 3.6	41.0 - 52.0	108 - 155
		bottom	12.2 - 15.7	1 - 90	6.7 - 7.3	1.5 - 10.6	41.0 - 58.0	116 - 155
C-6	1971	1m	16.0 - 23.6	94 - 105	7.3 - 7.6	1.5 - 4.3	41.8 - 54.0	99 - 160
		bottom	13.6 - 20.2	13 - 92	6.6 - 7.2	7.6 - 10.5	41.5 - 52.5	108 - 160

Data ranges for hardness, iron, total Kjeldahl nitrogen, phosphorus, chlorophyll a and Secchi disc for Stations C-4, C-5 and C-6 on Cameron Lake during 1971.

Table 2

Station	Date	Sample Depth	Hardness mg/l	Fe ppm	Nitrogen TKN mg/l N	Phosphorus Total mg/l P	Chloro a ug/l	Secchi Disc m
C-4	1971	Composite	52 - 60	.00 - .10	.13 - .34	.014 - .024	1.5 - 3.8	3.0 - 4.2
		Bottom	52 - 64	.00 - .15	.26 - .45	.015 - .080		
C-5	1971	Composite	52 - 62	.00 - .10	.20 - .32	.010 - .018	1.9 - 4.6	3.3 - 5.1
		Bottom	54 - 66	.00 - .20	.21 - .44	.014 - .020		
C-6	1971	Composite	54 - 62	.00 - .05	.21 - .38	.014 - .016	1.9 - 3.3	3.5 - 5.0
		Bottom	54 - 64	.00 - .10	.20 - .48	.013 - .028		

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where $S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$
N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey. If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs. SD refers to a significant difference at the .05 level but no significant difference at the .01 level. SD* refers to a significant difference at the .01 level but no significant difference at the .001 level. SD** refers to a significant difference at the .001 level.

Table 3

Summary of Analysis of Variance Grouping of Stations in 1971

Parameter - Total Coliform (TC)/100 ml

SURVEY	June 18 - 22	July 23 - Aug. 2	September 10 - 14
GROUP	All Stations	All Stations	All Stations
F	.674	1.120	.676
df	28, 79	28, 197	23, 73
F(.05)	1.622	1.545	1.681
	NSD	NSD	NSD
GROUP	A	A	A
	All stations	All stations	All stations
F	-	-	-
df	-	-	-
F(.05)	-	-	-
log GM	2.8129	1.5863	1.6605
SE	.0842	.0491	.0878
N	108	226	97
GM	650	39	46

Table 4

Summary of Analysis of Variance Grouping of Stations in 1971

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	June 18 - 22	July 23 - Aug. 2	September 10 - 14
GROUP	All Stations	All Stations	All Stations
F	.425	5.642	1.029
df	28, 60	28, 214	24, 83
F(.05)	1.663	1.541	1.653
	NSD	SD	NSD
GROUP	A	A	A
	All stations	All stations except 16, 19, 24, 26, 27, 16D	All stations
F	-	1.568	-
df	-	22, 170	-
F(.05)	-	1.61	-
	-	NSD	-
log GM	.9966	.465	.4574
SE	.1006	.0379	.0517
N	89	193	108
GM	10	3	3

Table 5

Summary of Analysis of Variance Grouping of Stations in 1971

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	June 18 - 22	July 23 - Aug. 2	September 10 - 14
GROUP	All Stations	All Stations	All Stations
F	1.632	2.989	1.285
df	28, 96	28, 213	24, 84
F(.05)	1.599	1.541	1.651
	SD	SD	NSD
GROUP	A	A	A
	All Stations except 11, 24	All Stations except 24	All Stations
F	.862	1.140	-
df	26, 87	27, 205	-
F(.05)	1.627	1.46	-
	NSD	NSD	-
log GM	.5529	.3015	.2910
SE	.0560	.0281	.0365
N	114	233	109
GM	4	2	2

Table 6

Summary of t-tests Between Major Analysis of Variance Groups (Group A)
Between Surveys

For Total Coliform

July	September	September
J t = 13.360	J t = .786	J t = 9.467
u df = 332 SD**	u df = 321 NSD	u df = 203 SD**
n t(.05) = 1.96	l t(.05) = 1.96	n t(.05) = 1.96
e	y	e

For Fecal Coliform

July	September	September
J t = 6.031	J t = .1193	J t = 5.011
u df = 280 SD**	u df = 299 NSD	u df = 195 SD**
n t(.05) = 1.96	l t(.05) = 1.96	n t(.05) = 1.96
e	y	e

For Fecal Streptococcus

July	September	September
J t = 4.482	J t = .218	J t = 3.881
u df = 345 SD**	u df = 340 NSD	u df = 221 SD**
n t(.05) = 1.96	l t(.05) = 1.96	n t(.05) = 1.96
e	y	e

Table 7

Summary of Analysis of Variance Grouping of Stations for Cameron Lake
August 17 - 21, 1970

Parameter	TC/100 ml	FC/100 ml	FS/100 ml
GROUP	A All Stations except 11, 12, 13 16, 8D	A All Stations	A All Stations except 11, 24
F	1.586	.997	1.5116
df	21, 73	26, 93	24, 89
F(.05)	1.75	1.620	1.61
	NSD	NSD	NSD
log GM	2.6534	1.1956	.3659
SE	.0291	.0650	.0429
N	95	120	114
GM	450	16	2
GROUP	B (Stations 11 - 13)		
F	.7145		
df	2, 11		
F(.05)	2.86		
	NSD		
log GM	3.1918		
SE	.1141		
N	14		
GM	1555		

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL <u>a</u>	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

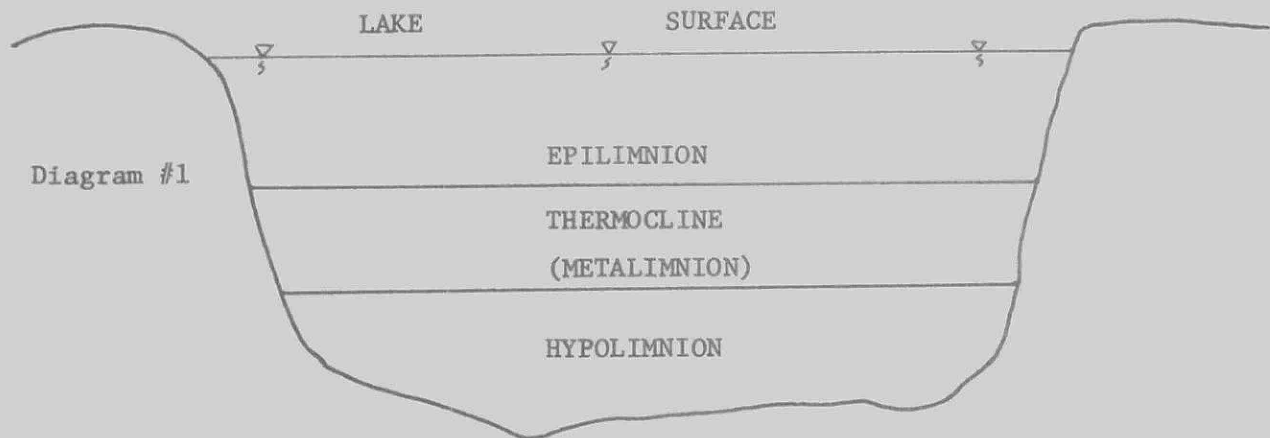
SECCHI DISC

:A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion)

:The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1°C increase per meter.



TOTAL COLIFORMS (TC) :Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS :Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic.

If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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Microbiological Criteria

Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

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